

# HYBRID COMPRESSOR AND CONTROL DEVICE

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is based on and incorporates herein by  
5 reference Japanese Patent Application No. 2002-203758 filed on  
July 12, 2002.

## FIELD OF THE INVENTION

The present invention relates to a hybrid compressor  
10 that is used mainly for a vehicular air-conditioning device and  
driven selectively by an engine or an electric motor, and its  
control device.

## BACKGROUND OF THE INVENTION

15 In a typical vehicular air-conditioning device, cooling  
cannot be executed due to no driving of a compressor while an  
engine of a vehicle stops. Recently, there are an idling-stop  
vehicle that stops its engine while temporary stop in the  
traveling and a vehicle that stops its engine even during the  
20 traveling depending on a condition. In these vehicles, a hybrid  
compressor that is driven by an engine while the engine is  
turned on and by an electric motor while the engine is turned  
off is used for obtaining comfortable cooling performance.

One of hybrid compressors and its controlling method are  
25 disclosed in JP-A-2000-110734. This hybrid compressor is  
furnished with a compression mechanism having a rotating shaft,  
an electric motor having an output shaft connected with the

rotating shaft, and an electromagnetic clutch connected with the output shaft. An engine is connected with the output shaft through the electromagnetic clutch. When the engine is in an operating state and the electromagnetic clutch is turned on, driving force of the engine is transmitted through the output shaft to the rotating shaft so that the compression mechanism can be driven. By contrast, when the engine is in a stopping state, the electromagnetic clutch is turned off, and the output shaft and the rotating shaft are thereby separated from the engine, the electric motor drives the compression mechanism using an electric power of a battery.

Furthermore, in the above hybrid compressor, a swash-plate type externally variable displacement compressor is adopted. In this compressor, a piston is driven by a rotation of a swash plate, and a displacement adjusting mechanism is externally adjusted, so that certain displacement can be obtained through varying of an inclination angle of the swash plate. In order to constantly optimizing cooling performance in a refrigerating cycle, the inclination angle of the swash plate is adjusted based on a cooling load so that the discharging displacement can be controlled.

The applicant of the present invention discloses, in JP-A-H10-291415, a method for enabling a motor of a hybrid compressor to be downsized and fitly mounted on a vehicle. In this hybrid compressor, a load of the motor is set to zero when the motor is turned on. The load of the motor is then increased after a revolution of the motor becomes stable.

However, in the above case, it takes an interval to return to required displacement after the displacement is once shifted to zero. In particular, when required heat capacity is low and target cooling capacity is low, it takes a longer interval to return to the required displacement. This results in inhibiting comfort of the air-conditioning for the interval.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a hybrid compressor that enables displacement is rapidly recovered when the compressor starts being driven by an electric motor.

To achieve the above object, a hybrid compressor is controlled as follow. When a hybrid compressor starts being driven by a motor, the hybrid compressor is operated by controlling a control device for operating at a first control value to thereby trigger a swash plate of the hybrid compressor to be rapidly inclined. The hybrid compressor is thereafter operated by controlling the control device for operating at a second control value than which the first control value is greater. This structure enables displacement of the hybrid compressor to be rapidly recovered.

In one aspect of the present invention, a control device includes a capacity control valve of the hybrid compressor. Here, the capacity control valve is operated at a first or second electric current applied to the capacity control valve as the first or second control value in the above, respectively. The first electric current is greater than the second electric

current that is obtained from a status of a refrigerating cycle.

In another aspect of the present invention, a control device includes the electric motor. Here, the electric motor is operated at a first or second revolution number as the first or second control value, respectively. The first revolution number is greater than the second revolution number.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

FIG. 1 is a schematic diagram showing overall structure of a vehicular air-conditioning system using a hybrid compressor according to an embodiment of the present invention;

FIG. 2 is a sectional view of a swash-plate type externally variable displacement compressor according to the embodiment;

FIG. 3 is a flow diagram explaining processing for main control of an ECU used in the vehicular air-conditioning system;

FIG. 4 is a graph showing relationship between refrigerant pressure of higher pressure portion and either of an initial control electric current of a control valve or initial control revolution number of a motor;

FIG. 5 is a flow diagram explaining compressor controlling in the flow chart of FIG. 3;

FIG. 6 is a flow diagram explaining processing of

controlling in motor driving according to a first embodiment;

FIG. 7 is a time chart showing operational contents in the motor driving according to the first embodiment;

FIG. 8 is a flow diagram explaining processing of controlling in motor driving according to a second embodiment; and

FIG. 9 is a time chart showing operational contents in the motor driving according to the second embodiment;

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First embodiment)

FIG. 1 shows overall structure of a vehicular air-conditioning system using a hybrid compressor according to an embodiment of the present invention. This embodiment is directed to a vehicle such a truck that conveys baggage. In this truck, in order to prevent an engine from continuing to be operating during loading or unloading baggage, the engine is turned off while the truck stops. When cooling capacity runs short, the engine is turned on.

In FIG. 1, an engine 1 is a driving source for vehicle traveling. An output shaft of the engine 1 is connected with a driving pulley 2 that is rotated in conjunction with the driving of the engine 1. The driving pulley 2 and a known electromagnetic clutch 3 that is for interrupting force are belted with a belt 7 that is for transmitting force. When the electromagnetic clutch 3 is engaged to be connected with a compressor 4 that is a part of a refrigerating cycle 5, the

compressor 4 is driven by the engine 1.

The compressor 4 can be also driven by a built-in electric motor 6 (direct current (DC) motor). The electric motor 6 is driven by being supplied with a power from an in-vehicle battery (not shown). The compressor 4 is driven selectively by either of the engine 1 or the electric motor 6.

Namely, in this embodiment, when the electric motor 6 drives the compressor 4 during a stopping state of the engine 1, coordination between the engine 1 and the compressor 4 is interrupted by disengaging the electromagnetic clutch 3. The compressor 4 is then driven by driving the motor 6. A one-way clutch can be also used as an electromagnetic clutchless type for switching the driving methods.

The refrigerating cycle 5 will be briefly explained below. FIG. 2 shows a sectional view of a swash-plate type externally variable displacement compressor according to the embodiment. In this compressor 4, a compression mechanism such as a piston 43 is driven by rotation of a swash plate 41. An internal pressure within a swash-plate chamber 42 is adjusted for an inclination angle of the swash plate 41 to be varied by an electromagnetic pressure capacity control valve (capacity control valve) 4a that is externally controlled (shown in FIG. 1). A discharging displacement is thereby varied based on the inclination angle of the swash plate 41.

A suction port 44 is fluidly connected with an outlet of an after-mentioned evaporator, while a discharge port 45 is fluidly connected with an inlet of an after-mentioned condenser.

A shaft 61 is a rotating shaft of the compressor 4 and also an output shaft of the electric motor 6. The electric motor 6 includes a stator 62 and a rotor 63 that is rotated with the stator 62. The shaft 61 is connected with the electromagnetic clutch 3 at its leftmost end of FIG. 2.

The refrigerating cycle 5 includes, as shown in FIG. 1, in addition to the compressor 4, known devices as follows: the condenser 11 where a refrigerant compressed by the compressor 4 is condensed and liquefied; a receiver 12 where the condensed and liquefied refrigerant is divided into a liquid phase and a gas phase; an expansion valve 13 where the liquid phase of the refrigerant is expanded and decompressed; and the evaporator 14 where the expanded refrigerant is evaporated.

The evaporator 14 is a heat exchanger for cooling of a vehicular air-conditioning system 100 through which a cabin (or vehicle compartment) of the vehicle is air-conditioned. The vehicular air-conditioning system 100, as is commonly known, includes an air-conditioning case 101 that is an air passage to the cabin and contains an air fan (blower) 102, the evaporator 14, a heater core 103, an air mix door 104, and the like. The heater core 103 is downstream from the evaporator 14, and a heat source of the core 103 is engine cooling water. The air mix door 104 is for adjusting temperature of an air-conditioning blow.

The electromagnetic clutch 3, the compressor 4, and the electric motor 6 are controlled by an electronic control unit (ECU) 15 as a control device. The ECU 15 is supplied with a power from an in-vehicle battery (not shown) when an ignition

switch (IG SW) that enables the vehicle traveling is turned on.

The ECU 15 is connected with output terminals as follows: a clutch control circuit 17; a motor drive circuit 18; and a displacement control circuit 19. The electromagnetic clutch 3 is controlled through the clutch control circuit 17 by the ECU 15. The electric motor 6 is controlled through the motor drive circuit 18 by the ECU 15. The capacity control valve 4a of the compressor 4 is controlled through the displacement control circuit 19 by the ECU 15.

The ECU 15 is connected with input terminals as follows: an outside air temperature sensor 20 for detecting air temperature outside the vehicle; an inside air temperature sensor 21 for detecting air temperature inside the cabin; an insolation sensor 22 for detecting an amount of the insolation incident inside the cabin; and a temperature adjuster 23 for setting a target air temperature inside the cabin. The ECU 15 is furthermore connected with a vehicle speed sensor 24 for detecting a vehicle speed, and an air-conditioning switch (SW) 25 for enabling automatic controlling of the vehicular air-conditioning system 100 based on a signal from the temperature adjuster 23.

Furthermore, the ECU 15 is connected with other input terminals as follows: a pressure sensor 26 for detecting a refrigerant pressure in a higher pressure portion of the refrigerating cycle 5; a revolution number sensor 27 for detecting a revolution number of the electric motor 6; an electric current sensor 28 for detecting an electric current for



driving the electric motor 6; and a temperature sensor 29 for detecting temperature of air (at an outlet of the evaporator 14) just after the air passes through the evaporator 14. In this embodiment, only when the air-conditioning switch 25 is turned on, the compressor 4 and the blower 102 can be automatically controlled.

Main control of the ECU 15 will be explained with reference to FIG. 3.

At Step 1, stored values are initialized when automatic control of the air-conditioning system 100 is started.

At Step 2, a target temperature that is set using the temperature adjuster 23 by a crew is read and other values such as temperatures are also read from the outside air temperature sensor 20, the inside air temperature sensor 21, the insolation sensor 22, the temperature sensor 29, and other water temperature sensors (not shown). These values are then properly corrected.

At Step 3, temperature air output (TAO) that is necessary blow temperature required for achieving the target temperature based on the temperature condition obtained at Step 2 is computed from a formula.

At Step 4, a motor controller's voltage for driving the blower 102 is controlled based on relationship between the necessary blow temperature TAO and a blower air amount (or blower voltage).

At Step 5, an opening degree of the air mix door 104 for achieving the necessary blow temperature TAO is determined based

on the necessary blow temperature TAO and the temperature condition obtained at Step 2, in accordance with a formula, and controlled through a servo motor (not shown).

At Step 6, one of blowing modes of a face mode, a foot mode, and a bi-level mode is determined and controlled through a servo motor (not shown). It is determined from the necessary blow temperature TAO based on blowing mode pattern data indicating relationship between the necessary blow temperature TAO and the blowing mode of air stream into the cabin.

At Step 7, the electromagnetic clutch 3, the electric motor 6, the capacity control valve 4a, and the like are controlled in after-mentioned processing of compressor controlling. The flow chart from Step 1 to Step 7 is repeated at approximately 0.25 second per cycle.

In the next place, the processing of the compressor controlling will be explained with reference to FIG. 5. This processing can be executed while the ignition switch 16 is turned on.

At Step 11, it is determined whether the air-conditioning switch 25 is tuned on. When the switch 25 is turned off, the vehicular air-conditioning system 100 is unnecessary to be operated for air-conditioning the cabin. The processing thereby proceeds to Step 12. Here, the electric motor 6 is turned off and the electromagnetic clutch 3 is disengaged. The compressor 4 is thereby turned off. When the switch 25 is turned on, the processing proceeds to Step 13.

At Step 13, it is determined whether a vehicle speed

detected through the vehicle speed sensor 24 is zero. When the speed is determined to be not zero (namely the vehicle is traveling), the processing proceeds to Step 14.

At Step 14, capacity control for the compressor 4 is executed using the capacity control valve 4a so that an air temperature detected through the temperature sensor 29 can reach the target temperature. Cooling load that is necessary for achieving the target temperature decreases with increasing target air temperature. The displacement of the compressor 4 decreases with decreasing cooling load. This results in enabling load of the engine 1 to be decreased. Thus, the capacity control is executed before the compressor 4 is driven by the engine 1.

At Step 15, under a condition controlled at Step 14, the electromagnetic clutch 3 is engaged, so that the compressor 4 is driven by the engine 1.

By contrast, when the vehicle speed is determined to be zero, the processing proceeds to Step 16.

At Step 16, it is determined whether the cooling load is greater than a preset value (namely whether rapid cooling down is necessary). The preset value is positioned between the maximum and the minimum of the selectable cooling capacity of the compressor 4. It is simultaneously determined whether a refrigerant circulating amount is greater than a preset value. For instance, outside air temperature is extremely high in summer, e.g., more than 30 °C, and inside air temperature is also high, e.g., more than 30 °C. In this case, the cooling load is greater than the preset value.

In the compressor 4 of the embodiment, the cooling load of the compressor 4 is indirectly estimated by detecting the outside and inside air temperatures, or applied electric current (duty) to the control valves. When the cooling load of the cabin is greater than the preset value, the processing proceeds to Steps 14 and 15. The compressor 4 is thereby driven by the engine 1.

When the cooling load is not greater than the preset value, the processing proceeds to Step 17.

At Step 17, the engine 1 is turned off and the electromagnetic clutch is disengaged. This situation is supposed when the truck arrives at a destination and temporarily stops for a certain loading or unloading work or when the truck waits at stop lights. Since the cooling load is not greater than the preset value and there is no need for driving the engine 1, the engine 1 is turned off while the ignition switch 16 is tuned on.

Here, during the certain work, the engine 1 is turned off, so that no exhaust gas leads to no pollution of atmosphere.

However, when the engine 1 is turned off and the compressor 4 is thereby turned off, the refrigerant does not circulate within the refrigerating cycle 5 and cooling capacity of the vehicular air-conditioning system 100 becomes zero. The air-conditioning of the cabin cannot be executed. When the cooling load is not greater than the preset value, the compressor 4 is consequently driven through activating the electric motor 6.

Namely, when the cooling load is not greater than the

preset value, the necessary capacity of the compressor 4 is less than the preset value and a circulating amount of the refrigerant is small. As a result, driving force for the compressor 4 is small, so that the compressor 4 can be driven by the electric motor 6.

By contrast, when the cooling load is greater than the preset value, the necessary capacity of the compressor 4 is not less than the preset value and the circulating amount of the refrigerant is not small. As a result, driving force for the compressor 4 is large, so that the compressor is driven by the engine 1 even while the vehicle stops.

Thus, even a compact electric motor 6 can drive the compressor 4. This leads to enhancing mountability of the electric motor 6. Furthermore, an externally variable displacement type is adopted for the compressor 4. When the cooling load is not greater than the preset value, the electric motor 6 drives the compressor 4. In comparison with adopting a fixed displacement type, the electric motor 6 needs even smaller driving force for the compressor 4. Consequently, a size of the electric motor 6 when the variable displacement type is adopted is smaller than that when the fixed displacement type is adopted.

At Step 18, low capacity control of the compressor is executed before the electric motor 6 drives the compressor 4. Here, the displacement is forcibly reduced to a minimum settable level (low capacity state) by controlling the capacity control valve 4a, and then the electric motor 6 is activated. The

capacity of the compressor 4 thereby becomes small, so that the driving force for the compressor 4 becomes smaller in comparison with a case where the capacity of the compressor 4 is large.

At Step 19, the compressor 4 is driven by the electric motor 6. Here, the electric motor 6 does not need to be a large size having large driving force by virtue of the above low capacity control at Step 18. This leads to furthermore enhancing downsizing a size of the electric motor 6 and thereby mountability of the electric motor 6. Although it is not shown, this low capacity state under the driving of the electric motor 6 continues till the engine 1 restarts. In the low capacity state, a revolution number of the electric motor 6 remains constant.

Although the refrigerating cycle 5 cannot sufficiently exert cooling capacity for cooling the cabin, cooling can be continued at some degree. For instance, while the truck stops for the loading/unloading work, temperature increase in the cabin is restricted. This results in relieving discomfort of the crew posterior to the loading/unloading work.

At Step 20, it is determined whether elapsed time of driving of the electric motor 6 is longer than a preset time T (e.g., two minutes). When the elapsed time is longer than the preset time T, the processing proceeds to Step 21.

At Step 21, the electric motor 6 is turned off for preventing the battery from running out. Here, the electric motor 6 can be turned off according to a result of detecting voltage or capacity of the battery.

Incidentally, the engine 1 can be naturally turned on for traveling of the truck even while the compressor 4 is driven by the electric motor 6. However, if the vehicle remains stopping (being at speed of zero), the engine 1 is shortly  
5 turned off. Therefore, once the ignition switch 16 is turned on, the engine 1 continues to be turned on for a certain period even when the vehicle remains stopping.

At Step 19, processing for motor driving is executed. The processing will be explained with reference to FIGs. 6 and  
10 7. FIG. 6 shows a flow chart of processing of controlling in the motor driving according to a first embodiment of the present invention, while FIG. 7 shows a time chart showing operational contents in the motor driving.

At Step 31 in FIG. 6, it is determined whether the  
15 electric motor 6 is turned off. When the electric motor 6 is determined to be turned off, the processing proceeds to Step 32.

At Step 32, an initial control electric current SS of the capacity control valve 4a is determined based on relationship, shown in FIG. 4, with refrigerant pressure of the  
20 higher pressure portion of the refrigerating cycle 5. The initial control electric current SS is greater than a control electric current S that is obtained from a state of the refrigerating cycle 5.

In FIG. 4, relationship between refrigerant pressure of  
25 the higher pressure portion and either of the initial control electric current SS or an initial control revolution number SR of the electric motor 6 is shown. The initial control electric

current SS and the initial control revolution number SR are increasing with increasing refrigerant pressure of the higher pressure portion.

At Step 33, electric current is applied to the electric motor 6 for driving the electric motor 6 at a preset revolution number R.

At Step 34, it is determined whether the preset revolution number R is reached. When the preset revolution number R is determined to be reached, the processing proceeds to Step 35.

At Step 35, the initial control electric current SS determined at Step 32 is applied to the capacity control valve 4a, as shown in FIG. 7. This triggers the swash plate 41 to be rapidly inclined.

At Step 36, it is determined whether a preset time T1 elapses. When the preset time T1 elapsed, the processing proceeds to Step 37.

At Step 37, the electric current of the capacity control valve 4a is converged, at a preset time T2, to the control electric current S that is obtained from the state of the refrigerating cycle 5.

At Step 38, the electric current is controlled to remain at the control electric current S. Hereafter, when the electric motor 6 is determined to be not turned off at Step 31, the processing proceeds to Step 38, where the electric current of the capacity control valve 4a is repeatedly controlled to remain at the control electric current S.



Features of this embodiment will be described. In the swash-plate type externally variable displacement compressor of this embodiment, once the displacement starts being recovered by virtue of inclination of the swash plate, force is apt to be applied for the displacement to increase. This tendency is utilized in this embodiment. The initial control electric current SS is greater than a control electric current S that is obtained from a state of the refrigerating cycle 5. The initial control electric current SS is applied as a trigger for inclination of the swash plate. When the compressor 4 starts being driven by the electric motor 6, the displacement of the compressor 4 can be thereby rapidly recovered.

Furthermore, the pressure sensor 26 is provided for detecting the refrigerant pressure in the higher pressure portion of the refrigerating cycle 5. According to the refrigerant pressure in the higher pressure portion, the initial control electric current SS is varied. The initial control electric current SS is thereby set based on the cooling load of the refrigerating cycle 5.

After the compressor 4 starts being driven by the electric motor 6, the initial control electric current SS continues to be used as a target only for the preset time T1. If the swash plate starts being inclined and the initial control electric current SS still continues to be used at the target more than the preset time T1, excessive cooling or wasteful power consumption may occur. The preset time T1 is suitable just for triggering the swash plate to start being inclined.

As another aspect, the revolution number sensor 27 is provided for detecting the revolution number of the electric motor 6. After the compressor 4 starts being driven by the electric motor 6, decrease  $\Delta A$  from a preset revolution number R is detected, as shown in FIG. 7. By detecting the decrease  $\Delta A$ , the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. The decrease of the revolution number of the motor 6 means that the swash plate 41 starts being inclined. This structure can also restrict the excessive cooling or wasteful power consumption.

As another aspect, the electric current sensor 28 is provided for detecting the electric current for driving the electric motor 6. After the compressor 4 starts being driven by the electric motor 6, decrease  $\Delta B$  from a required value is detected as shown in FIG. 7. By detecting the decrease  $\Delta B$ , the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. The decrease of the electric current of the motor 6 also means that the swash plate 41 starts being inclined. This structure can also restrict the excessive cooling or wasteful power consumption.

As yet another aspect, the temperature sensor 29 is provided for detecting temperature of air (at the outlet of the evaporator 14) just after the air passes through the evaporator 14. After the compressor 4 starts being driven by the electric

motor 6, a shifting point C at which air temperature that has been increasing starts to decrease is detected as shown in FIG. 7. By detecting the shifting point C, the electric current of the capacity control valve 4a can start to converge from the initial control electric current SS to the control electric current S. Since the displacement of the compressor 4 is recovered, the increasing air temperature starts to again decrease and the shifting point C is detected. This structure can also restrict the excessive cooling or wasteful power consumption.

The electric current of the capacity control valve 4a converges from the initial control electric current SS to the control electric current S at the preset time T2. This enables gradual shift to usual control, so that worsening of cooling feeling is prevented. Furthermore, providing the above control device in the compressor 4 enables adopting the swash-plate type externally variable displacement compressor that rapidly recovers displacement when the compressor 4 starts being driven by the motor 6.

(Second embodiment)

A second embodiment will be explained with reference to FIGs. 8 and 9. The second embodiment is different from the first embodiment only regarding the motor controlling of the ECU 15.

At Step 41 in FIG. 8, it is determined whether the electric motor 6 is turned off. When the electric motor 6 is determined to be turned off, the processing proceeds to Step 42.

At Step 42, an initial control revolution number SR of

the electric motor 6 is determined based on relationship with the refrigerant pressure of the higher pressure portion shown in FIG. 4. The initial control revolution number SR is greater than the preset revolution number R.

5           At Step 43, electric current is applied to the electric motor 6 for driving the electric motor 6 at the initial control revolution number SR determined at Step 42.

          At Step 44, it is determined whether the initial control revolution number SR is reached. When the initial control  
10   revolution number SR is determined to be reached, the processing proceeds to Step 45.

          At Step 45, the control electric current S that is obtained from a state of the refrigerating cycle is applied to the capacity control valve 4a, as shown in FIG. 9. This triggers  
15   the swash plate 41 to be rapidly inclined.

          At Step 46, it is determined whether a preset time T1 elapses. When the preset time T1 elapsed, the processing proceeds to Step 47.

          At Step 47, the revolution number of the electric motor  
20   6 is converged, at a preset time T2, to the preset revolution number R from the initial control revolution number SR.

          At Step 48, the revolution number is controlled to remain at the preset revolution number R. Hereafter, when the electric motor 6 is determined to be not turned off at Step 41,  
25   the processing proceeds to Step 48, where the revolution number is repeatedly controlled to remain at the preset revolution number R.

Features of this embodiment will be described. As explained in the first embodiment, in the swash-plate type externally variable displacement compressor of this embodiment, once the displacement starts being recovered by virtue of inclination of the swash plate, force is apt to be applied for the displacement to increase. This tendency can be also utilized in this embodiment. The initial control revolution number SR is greater than the preset revolution number R. The initial control revolution number SR is used as a trigger for inclination of the swash plate. Since inertia of the swash plate is increased, the displacement of the compressor 4 can be rapidly recovered when the compressor 4 starts being driven by the electric motor 6.

Furthermore, the pressure sensor 26 is provided for detecting the refrigerant pressure in the higher pressure portion of the refrigerating cycle 5. According to the refrigerant pressure in the higher pressure portion, the initial control revolution number SR is varied. The initial control revolution number SR is thereby set based on the cooling load of the refrigerating cycle 5.

After the compressor 4 starts being driven by the electric motor 6, the initial control revolution number SR continues to be used as a target only for the preset time T1. If the swash plate starts being inclined and the initial control revolution number SR still continues to be used at the target more than the preset time T1, excessive cooling or wasteful power consumption may also occur. The preset time T1 is suitable just for triggering the swash plate to start being inclined.

As another aspect, the temperature sensor 29 is also provided for detecting temperature of air (at the outlet of the evaporator 14) just after the air passes through the evaporator 14, as explained in the first embodiment. After the compressor 4 starts being driven by the electric motor 6, a shifting point C at which air temperature that has been increasing starts to decrease is detected in FIG. 9. By detecting the shifting point C, the revolution number can start to converge from the initial control revolution number SR to the preset revolution number R. This structure can also restrict the excessive cooling or wasteful power consumption.

The revolution number of the electric motor 6 converges from the initial control revolution number SR to the preset revolution number R at the preset time T2. This enables gradual shift to usual control, so that worsening of cooling feeling is prevented. Furthermore, providing the above control device in the compressor 4 enables adopting the swash-plate type externally variable displacement compressor that rapidly recovers displacement when the compressor 4 starts being driven by the motor 6.

(Modification)

The first and second embodiments can be modified below.

Although the initial control electric current SS and the initial control revolution number SR are varied based on the refrigerant pressure of the higher pressure portion, these initial control values can be constant values.

The electric current of the capacity control valve 4a

converges from the initial control electric current SS to the control electric current S at the preset time T2. The revolution number of the electric motor 6 converges from the initial control revolution number SR to the preset revolution number R at the preset time T2. However, gradual shift that needs the preset time T2 is not always necessary. Instance shift that does not need a certain period can be used instead of the gradual shift.

While the compressor 4 is driven by the motor 6, the revolution number of the electric motor 6 remains constant. However, the revolution number can be variable according to the cooling load. In the above hybrid compressor, the compression mechanism 4 and the electric motor 6 are integrally assembled. However, the compression mechanism can be a simple body. In this case, a rotation shaft of the compression mechanism is provided with an electromagnetic clutch and a pulley. The pulley is connected separately with an engine and an electric motor through belts, so that the compression mechanism is driven selectively by the engine or the electric motor.

The refrigerating cycle 5 is for cooling the cabin of the vehicle. However, it can be for cooling a refrigerator or a freezer. In this case, cooling for the refrigerator or the freezer can be continued during the loading/unloading work in the truck.

The present invention can be directed to a so-called hybrid vehicle that travels by a driving source of either an engine or an electric motor. It can be also directed to a

vehicle having an engine dedicated for generating electricity.  
In this vehicle, an electric motor that is driven by the  
electricity generated by the engine is used for driving source  
of vehicle traveling. Furthermore, the present invention can be  
5 directed to not only a vehicle but also a stationary  
refrigerating cycling device driven by an engine.

It will be obvious to those skilled in the art that  
various changes may be made in the above-described embodiments  
of the present invention. However, the scope of the present  
10 invention should be determined by the following claims.